

PROJECT ADMINISTRATION DATA SHEET

☒ ORIGINAL

☐ REVISION NO. \_\_\_\_\_

Project No. D-48-653 DATE: 5/21/81

Project Director: Dr. John C. Archea School/Lab Architecture

Sponsor: National Science Foundation; Washington, D.C. 20550

Type Agreement: Grant No. CEE-8107222

Award Period: From 4/15/81 To 12/31/82\* (Performance) \_\_\_\_\_ (Reports) \_\_\_\_\_

Sponsor Amount: \$47,757 Contracted through: \_\_\_\_\_

Cost Sharing: \$581 (D-48-322) GTRI/~~GIT~~

Title: "Research Initiation: The Behavior of Building Occupants During Earthquakes"

ADMINISTRATIVE DATA OCA CONTACT Leamon R. Scott

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Reports: See Deliverable Schedule Security Classification: unclassified

Defense Priority Rating: N/A

RESTRICTIONS

See Attached NSF Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval - Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of \$500 or 125% of approved proposal budget category.

Equipment: Title vests with GIT

COMMENTS: \* Includes the usual six (6) month unfunded flexibility period.

COPIES TO:

Administrative Coordinator	Research Security Services	EES Research Public Relations
Research Property Management	Reports Coordinator (OCA)	Project File (OCA)
Accounting Office	Legal Services (OCA)	Other: _____
Procurement/EES Supply Services		

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date2/4/87

Project No.D-48-653School/446Architecture

Includes Subproject No.(s)N/A

Project Director(s)John ArcheaGTRC / GTR

SponsorNational Science Foundation; Washington, D. C. 20550

Title "Research Initiation: The Behavior of Building Occupants During Earthquakes"

Effective Completion Date: 12/31/83 (Performance) 3/31/84 (Reports)

Grant/Contract Closeout Actions Remaining:

- ☐ None
- ☐ Final Invoice or Final Fiscal Report
- ☐ Closing Documents
- ☒ Final Report of Inventions Questionnaire sent to P. I.
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other

Continues Project No. Continued by Project No.

COPIES TO:

- Project Director

Research Administrative Network

Research Property Management

Accounting

Procurement/GTRI Supply Services

Research Security Services

Reports Coordinator (OCA)

Legal Services
- Library

GTRC

~~Research Communications (2)~~

Project File

Other Ina Lashley

Angela Jones

Russ Embry



PLEASE READ INSTRUCTIONS ON REVERSE BEFORE COMPLETING

PART I-PROJECT IDENTIFICATION INFORMATION

1. Institution and Address Georgia Institute of Technology College of Architecture Atlanta, GA 30332-0155	2. NSF Program Earthquake Hazards Mitigation	3. NSF Award Number
	4. Award Period From 04/15/81 to 12/31/83	5. Cumulative Award Amount \$47,757
6. Project Title The Behavior of Building Occupants During Earthquakes		

PART II-SUMMARY OF COMPLETED PROJECT (FOR PUBLIC USE)

The major questions addressed in this study were (1) how much activity can people actually pursue during the period of strongest ground motion caused by an earthquake and (2) do they attempt to do any more than the minimal amount of activity required to protect themselves? The March 21, 1982 earthquake near the town of Urakawa on the south coast of Hokkaido was selected as the site for this study because (a) it was the strongest earthquake to strike an inhabited area during 1982, (b) most structures remained sufficiently intact to permit on-site investigations after the incident, and (c) the residents of the town were minimally grief stricken because there were few serious casualties.

A total of 41 persons who had been in their homes at the time of the earthquake were interviewed in August, 1982. The subjects were selected on the basis of the calculated intensity of the tremor in the vicinity of their homes. Three independent series of questions were asked pertaining to (a) the respondent's own actions during the period of strongest ground motion, (b) the respondent's observations of any structural or non-structural displacement during this period, and (c) the respondent's observations of the actions taken by other people during this period.

An analysis of the sample of 41 respondents revealed that they engaged in an average of five distinct actions during the 30 seconds of strong shaking. The subjects traveled an average of 27 feet from the time they first noticed the earthquake to the time that the strongest shaking stopped. Six subjects traveled over 50 feet during this period, with the greatest distance traveled being 174 feet.

Very few of the subjects attempted to protect themselves from falling objects during the earthquake itself. This appears to have been due to the fact that there were very few pieces of furniture available within these homes that were large enough to provide refuge. In addition, it was found that the distances that subjects would have to have traveled to reach an available refuge zone were so great that other options, such as going outside, became equally or more attractive.

See Attachment

PART III-TECHNICAL INFORMATION (FOR PROGRAM MANAGEMENT USES)

1. ITEM (Check appropriate blocks)	NONE	ATTACHED	PREVIOUSLY FURNISHED	TO BE FURNISHED SEPARATELY TO PROGRAM	
				Check (✓)	Approx. Date
a. Abstracts of Theses	XX				
b. Publication Citations		XX			
c. Data on Scientific Collaborators	XX				
d. Information on Inventions	XX				
e. Technical Description of Project and Results		XX			
f. Other (specify) Survey Instrument					
2. Principal Investigator/Project Director Name (Typed) John Archea	3. Principal Investigator/Project Director Signature			4. Date 01/16/87	

An unexpectedly high percentage of the subjects attempted to protect their property by bracing their furniture with their bodies or by holding onto small appliances and utensils. The urge to protect property appeared to be quite strong, since many of the subjects walked directly past an available zone of refuge enroute to taking such action. None of the subjects who attempted to protect their property succeeded and two were struck by the cabinets or by their contents as they fell. This suggests that, despite the apparent urgency, such action unnecessarily increased the risk of casualty.



1. Site Number \_\_\_\_\_
2. Interview Number \_\_\_\_\_
3. Interviewer \_\_\_\_\_
4. Age: 5-17 18-25 26-40 41-64 65 or older
5. Sex: M F
6. Role in the Building: Resident Employee Visitor
7. Profession/Occupation: \_\_\_\_\_
8. Length of Residence/Employment in Building: \_\_\_\_\_
9. Education: \_\_\_\_\_
10. Where were you when the earthquake began?

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11. Where were you when the earthquake ended?

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12. Were there any other people present during the earthquake?

_____	_____
_____	_____
_____	_____
_____	_____

13. Where were these people when the earthquake began?

_____	_____
_____	_____
_____	_____
_____	_____

14. What were you doing when the earthquake began?

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15. How long had you been doing this?

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16. What was it that first alerted you to the earthquake?

- a. Felt the building move
- b. Saw furniture or equipment move
- c. Heard rumbling noise
- d. Heard or saw objects fall to the ground
- e. The lights went out
- f. Someone told me(us)
- g. Other \_\_\_\_\_

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[illegible]

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[illegible]



34. Could you see any other people around you during the earthquake?
35. Where were they when you noticed them?
36. What were they doing?
37. Where were you located when you first noticed these people?
38. In what order did you see each of these people?  
(third walkthrough)

**SECONDARY PERSONNEL CHART**

O.P. 34	LOCATION 35	ACTIVITY 36	VANTAGE POINT 37	SEQ. 38

39. Why do you think you took the steps that you did during the earthquake?

- a. Previous training
- b. Previous training within this structure
- c. Previous experience in earthquakes
- d. Previous experience in earthquakes within this building
- e. Seemed like the only thing to do
- f. I don't know
- g. Advice from someone else during the earthquake
- h. I expected the earthquake to hit
- i. Other \_\_\_\_\_

40. How long do you think the earthquake lasted?

- |                  |                      |
|------------------|----------------------|
| a. 1-10 seconds  | g. 1-1½ minutes      |
| b. 11-20 seconds | h. 1½-2 minutes      |
| c. 21-30 seconds | i. 2-3 minutes       |
| d. 31-40 seconds | j. 3-4 minutes       |
| e. 41-50 seconds | k. 4-5 minutes       |
| f. 51-60 seconds | l. 5 or more minutes |

41. Did you do everything that you listed during that time?

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42. What did you do immediately after the earthquake stopped?

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The Behavior of Building Occupants During Earthquakes

SUMMARY OF PUBLICATIONS AND PRESENTATIONS:

Archea, John; Kobayashi, Masami; The Behavior of People in Dwellings During the Off-Urakawa Earthquake of March 21, 1982; in the Proceedings of the Eighth World Conference on Earthquake Engineering, Volume V. Englewood Cliffs, NJ, Prentice-Hall, 1984.

- preliminary presentations to:

Interagency Panel on Earthquake Hazards Mitigation, National Science Foundation, Washington, D.C., April 22, 1983.

Workshop on Designing for Personal Control in Hazards and Disasters, Annual Conference of the Environmental Design Research Association, Lincoln, Nebraska, April 23, 1983.

- final presentation to:

Eighth World Conference on Earthquake Engineering, International Association for Earthquake Engineering, San Francisco, July 24, 1984.

Archea, John; Kobayashi, Masami; Behavior During Earthquakes: Coping With the Unexpected in Destabilizing Environments, in Ittelson, William; Asai, Masaaki; Ker, Mary (Eds.) Proceedings of the Second U.S.-Japan Conference on Environment-Behavior Research. Tucson, University of Arizona Press, 1986.

- preliminary presentations to:

Workshop on Human Behavior in Buildings During Earthquakes, Annual Meeting of the Earthquake Engineering Research Institute; Seattle, February 8, 1985.

College of Architecture and Urban Planning, University of Washington, Seattle, February 12, 1985

- final presentations to:

Second U.S.-Japan Seminar on Environment-Behavior Research, Tucson, October 7, 1985.

Ninth Conference of the International Association of People and Their Physical Surroundings, Haifa, Israel, July 10, 1986.

THE BEHAVIOR OF PEOPLE IN DWELLINGS  
DURING THE OFF-URAKAWA EARTHQUAKE OF MARCH 21, 1982

J. Archea (I)  
M. Kobayashi (II)  
Presenting Author: J. Archea

SUMMARY

This study utilized an in-depth interview procedure to reconstruct the courses of action taken by 41 inhabitants of dwellings during the off-Urakawa earthquake of March 21, 1982 and to identify the relationships between those actions and the performance of the building systems, sub-systems, and contents which surrounded them during the period of strongest ground motion.

INTRODUCTION

It is often assumed that, during major earthquakes, the ground motion will be too strong or the time will be too short for building occupants to pursue any actions which could affect their own survival or that of others. Until now there has been very little research to justify these assumptions. The few studies which have been published suggest that a great deal of activity may actually occur during earthquakes and that some of these activities may have unanticipated negative consequences for those who pursue them (Refs. 1 and 2). Similarly, recent research on human behavior during building fires has shown that people often respond to such emergencies with a subjective kind of rationality which may appear to have been totally counter-productive when viewed after-the-fact by uninvolved observers (Refs. 3 and 4).

Following the lead taken by researchers in the fire area, this study focused on the courses of action taken by building occupants during a specific earthquake and on the relationships between those actions and the performance of surrounding building elements, furnishings, and other occupants while the earthquake was occurring. The major questions addressed by this study were:

- (1) How much activity can people actually pursue during the period of strongest ground motion caused by an earthquake?
- (2) Do they attempt to engage in any more than the minimal amount of activity required to protect themselves?

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(I) Associate Professor of Architecture Georgia Institute of Technology, Atlanta, Georgia, U.S.A.

(II) Instructor in Architectural Engineering, Kyoto University, Kyoto, Japan.



## SETTING

The March 21, 1982 earthquake near Urakawa on the southern coast of Hokkaido, Japan was selected as the setting for this study for the following reasons:

(a) it was the strongest earthquake to strike an inhabited area in an accessible part of the world during 1982

(b) despite extensive building damage, most structures remained sufficiently intact to permit on-site investigations after the event

(c) there were too few serious casualties to create widespread grief reactions among the potential subjects.

Urakawa is a fishing and horse breeding community with a population of 19,408 as of 1980. It is near the center of a very active seismic zone. In 1952 and 1968 earthquakes registering 8.1 and 7.9 on the Richter Scale were centered approximately 150 kilometers east and 250 kilometers southeast of the town, respectively. In January, 1981 Urakawa experienced an earthquake with a magnitude of 6.7 on the Richter Scale. In the 14 months between January, 1981 and March 21, 1982, noticeable tremors were being experienced in Urakawa almost every day. Given the frequency with which they had been experiencing foreshocks and the relatively low casualty rates that were reported, it would appear that the residents of Urakawa were about as well prepared for the earthquake of March 21 as could be expected.

The March 21, 1982 tremor struck at 11:32:20 AM on a Sunday morning. The period of strongest ground motion lasted 30 seconds. This earthquake had a magnitude of 7.1 on the open-ended Richter Scale. Using the scale adopted by the Japan Meteorological Agency, it was determined to have had an intensity between 5.0 and 6.0 at various locations in the center of Urakawa. This corresponds to an intensity between 9.0 and 10.0 on the Modified Mercalli Scale.

There were 141 damaged dwellings in the town of Urakawa. However, most of these continued to be occupied after the earthquake. An additional 545 dwellings were damaged in adjacent communities. Forty-two percent of all the injuries that were recorded for the March 21 earthquake occurred in the town of Urakawa. Only 9 of the 82 injuries that occurred in Urakawa were listed as serious. There were no fatalities.

## PROCEDURE

A total of 41 persons who had been in their homes at the time of the March 21 earthquake were interviewed in August, 1982. This was approximately 5 months after the event. All interviews took place in the settings that the subjects had actually occupied during the earthquake. Subjects were selected on the basis of the calculated intensity of the tremor in the general vicinity of their homes, using data on the extent of structural damage that had been compiled by Professor Yutaka Ohta and Ms. Hitomi Ohashi at Hokkaido University in Sapporo (Ref. 5).

The sample included 15 and 16 subjects, respectively, from Tokiwamachi and Higashimachi, which were the two districts in which the intensity of the earthquake was found to have been greatest. There were 7 subjects from Sakaimachi which is situated on an alluvial plain in which the shaking was somewhat less intense. The remaining 3 subjects were from the outlying district of Ogifushi.

In addition to obtaining background data on matters like age and the state of the household at the time of the earthquake, each subject was asked three series of questions pertaining to:

(a) the sequence of their own actions during the 30-second period of strongest ground motion

(b) the sequence in which they observed any structural or non-structural displacement during this period

(c) their observations of the activities of other occupants of the dwelling during the earthquake.

On the assumption that people create accounts of their experiences in disaster situations to justify their contributions to the final outcome, the subjects were initially encouraged to report what they did or saw just as they remembered it. The remaining questions were ordered in such a way that successive responses would refine and correct the data on the sequence in which each of the reported actions actually occurred. Specific questions were asked about the locations at which each activity took place or was attempted and the vantage points from which damage or the behavior of others was observed.

Each subject also walked through the entire sequence of activities which they had pursued during the 30-second period of strongest ground motion. Their paths of travel, the locations at which all reported actions were taken, and the points from which they observed specific events around them were then plotted on measured floor plans which were made for each dwelling.

## FINDINGS

Detailed analysis of the field data indicates that the subjects engaged in an average of 5 distinct actions during the 30-second period of strongest ground motion. Thirteen of the 41 subjects (31.7%) reported that, when the shaking started, they just stayed where they were until they determined its severity. Most of these subjects eventually pursued other activities. Only six subjects (14.6%) remained in the same location throughout the entire period of strong ground motion.

The distances-travelled from the time that the subjects first noticed the earthquake to the time that the strongest shaking stopped, averaged 27 feet. Six subjects moved more than 50 feet during this period, with the greatest distance travelled being 174 feet. Although this seems like a great distance, a person travelling at a normal fast walking pace of 7 feet-per-second (Ref. 6) could have gone 210 feet in the same 30-second period.

The specific activities pursued by the subjects were related to reducing the risk of fire, protecting one's property, going outside, and protecting oneself. Each of these activities will be presented in turn.

### Reducing the Risk of Fire

Nineteen of the 41 subjects (46.4%) acted to reduce the possibility of fire by turning off their portable oil stoves. These 19 subjects travelled an average of 9'-3" to turn their oil stoves off. In a typical Japanese house, this is equivalent to moving all the way across a room. Interestingly, most of these oil stoves were known to have been equipped with automatic flame suppression devices (although it was reported that these were only 90% effective during the 1982 earthquake).

In other action intended to reduce the possibility of fire, seven subjects (17.1%) turned off the gas cock behind the kitchen range. They travelled an average of 5'-10" to do so. Twenty-one of the 26 instances of turning off oil stoves and gas cocks (80.8%) were listed among the first two actions taken by the subjects. This suggests that reducing the risk of fire was a very high priority for the dwelling occupants interviewed in this study.

### Protecting Property

Sixteen of the subjects (39.0%) attempted to brace free-standing cabinets or bookshelves with their bodies in order to keep these furnishings and their contents from falling to the floor. They travelled an average of 9'-4" to do this. This suggests that they were not simply trying to keep these things from falling on top of themselves, but were actively moving across a room to protect their property. Note that most of this property was not insured.

None of these 16 subjects were successful in keeping their furniture from falling (although many of them had been successful during the less intense earthquake in 1981). Two of these subjects (12.5%) were struck by a falling object while they tried to brace their cabinets.

In addition, seven subjects (17.1%) reported that they tried to hold onto other objects to keep them from falling or breaking. Since this group travelled an average of only 4'-8" to hold these objects, it would appear that this action was more fortuitous than deliberate.

Although a few subjects attended to their possessions right away, the percentage who braced cabinets or kept objects from falling tended to increase as the earthquake progressed. The average distance travelled to protect property also tended to increase throughout the period of strongest ground motion. This suggests that actions directed toward property became less fortuitous and more goal directed over time.

### Going Outside

Ten of the subjects (24.4%) actually ran out of their house or apartment at some point during the earthquake. Six more attempted to go



outside, but were unable to do so. Those who succeeded in getting out travelled an average of 18'-1" from the point at which their previous activity had occurred to their destination outside.

Three of the 10 subjects who went outside (30.0%) changed from their house slippers to their street shoes as they passed the entry hall. Two subjects (20.0%) fell on their entry stairs as they went outside.

### Protecting Oneself

Only 3 of the 41 subjects (7.3%) tried to protect themselves from falling objects by getting under a piece of furniture or some other cushioning device. Only two of them were successful.

One woman successfully got under a folding mattress that was normally used for sleeping. Another woman ducked into the bottom of her bedroom closet where she was cushioned by the clothes hanging above her. The subject who was unsuccessful reported that, as she tried to get under her kitchen table, her refrigerator was falling onto the table and another cabinet was falling onto the refrigerator.

These three subjects travelled an average of 15'-9" to seek safe refuge. This means that, in order to protect themselves, they had to travel to another room. Comparing the 10 subjects who chose to travel an average of 18'-1" to go outside with the 3 subjects who travelled an average of 15'-9" to take cover, suggests that the former course of action was perceived to be more advantageous than the latter.

It was also found that there were very few pieces of furniture that a person could have gotten under in the 27 homes studied. When the earthquake began, only 8 of the 41 subjects (19.5%) were in a room which contained a piece of furniture that could have afforded them protection. Eight more of the subjects (a total of 39.0%) passed through a room that provided such refuge as the earthquake continued.

Of the 14 instances in which a subject passed directly next to a piece of furniture that could have provided safe refuge, only one (7.1%) resulted in an attempt to protect oneself. That attempt was the one that was unsuccessful. The remaining 13 subjects travelled an average of 19'-0" after passing a potential place of refuge. Three of these subjects (23.1%) eventually went outside.

### CONCLUSIONS

Based on the data from the March 21, 1982 Off-Urakawa earthquake, the following conclusions emerge:

(1) The subjects were able to engage in a number of different kinds of activities and to travel considerable distances during the 30-second period of strong ground motion.

(2) The most prevalent and immediate responses were associated with reducing the subsequent risk of fire. This may be uniquely related to

housing conditions in Japan (especially the use of portable oil stoves to provide heat and humidity during the winter months).

(3) Very few of the subjects attempted to protect themselves from falling objects during earthquake itself. This appears to have been due to the following factors:

(a) there were very few pieces of furniture available within these houses that were large enough to provide refuge

(b) the paths to the refuge zones that were available were often obstructed by falling or shifting objects

(c) the distances that subjects would have to have travelled to reach an available refuge zone were so great that other options, such as going outside, became equally or more attractive.

(4) An unexpectedly high percentage of the subjects attempted to protect their property by bracing their furniture with their bodies or by holding onto small appliances and utensils.

(5) The urge to protect property appeared to be quite strong, since many of the subjects walked directly past an available zone of refuge enroute to taking such action.

(6) None of the subjects who attempted to protect their property succeeded and two were struck by the cabinets or by their contents as they fell. This suggests that, despite the apparent urgency, such action unnecessarily increased the risk of casualty.

Although these findings are based on a small number of respondents who had experienced a single earthquake, they do suggest that the behavior of building occupants may be a much more critical factor in survival or casualty during earthquakes than has generally been acknowledged. Specifically, they suggest that people may be able to engage in much more activity during the period of strong shaking than has been thought to be possible or appropriate. Clearly further research on the nature of human behavior during earthquakes will be essential for the development of effective public information programs or refuge zone strategies for building occupants.

#### REFERENCES

1. Arnold, C.; Durkin, M.; Eisner, R. & Whitaker, D. Imperial County Services Building: Occupant Behavior and Operational Consequences as a Result of the 1979 Imperial Valley Earthquakes. Building Systems Development, Inc., San Mateo, California, August, 1982.
2. Ohta, Y.; & Ohashi, H. A Field Survey on Human Response During and After an Earthquake. Proceedings of the Seventh World Conference on Earthquake Engineering, Istanbul, September, 1980. 9, pp. 353-359.

3. Canter, D. (Ed.) Fires and Human Behaviour. John Wiley & Sons, New York, 1980.
4. Keating, J. The Myth of Panic. Fire Journal, May 1982, pp. 57-61.
5. Ohashi, H.; Fujibayashi, K.; & Ohta, Y. Intensive Seismic Intensity Survey on the 1982.3.21 Urakawa-Oki Earthquake. General Report on the Urakawa-Oki, Japan, Earthquake of March 21, 1982. Data Center for Natural Disasters, Hokkaido University, December, 1982.
6. Murray, P. Comparison of Free and Fast Speed Walking Patterns of Normal Men. American Journal of Physical Medicine, 1966, 45, pp. 8-24.



## BEHAVIOR DURING EARTHQUAKES:

### COPING WITH THE UNEXPECTED IN DESTABILIZING ENVIRONMENTS

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#### Introduction

Throughout the environment-behavior literature, the physical environment tends to emerge as a uniform and stable backdrop against which the interpersonal consequences of user capabilities, expectations, and intentions are played out. The uniformity and stability of the environment is seldom questioned.

The possibility that the physical environment is not uniform from one position to another has been presented elsewhere. According to this view, the interpersonal opportunities and obligations present at one location within a room may be quite different than those present at nearby locations within the same room (Archea, 1977, 1980, 1984a).

This paper extends the notion that the environment is spatially and temporally variable by considering situations in which the arrangements and architectural attributes of rooms, buildings, and other settings change unexpectedly and dramatically from one moment to the next. The September 19, 1985 earthquake that has just devastated several sections of Mexico City is a potent reminder that events like the San Francisco (1906), Kanto (1923), Fukui (1948), and Tangshan (1976) earthquakes lie in our future, as well as in our past. Despite the fact that earthquakes, flash floods, and fires are legitimate areas of research on environment and behavior from strictly a hazards mitigation viewpoint, the intent of considering them in this paper is to advance the proposition that the physical environment should be treated as an experientially salient and empirically accessible variable in all environment-behavior research.

Although findings are fragmented, research reported to date suggests that

there is a common pattern of responses to abruptly destabilizing environments. In the case of fire, these include (a) delaying any response until a second and independent alarm or cue is received (Loftus & Keating, 1974); (b) searching for the source of the fire in the absence of independent confirmation (Canter, 1980); (c) exiting via the most familiar, rather than the most direct or least hazardous routes (Bickman, 1977; Edelman, Herz, & Bickman, 1980; Horiuchi, 1978); and (d) returning to the threatened area after reaching safety (Lerup, Cronrath, & Liu, 1980).

The same pattern of initial responses has been found in earthquakes, except searching for the source--which makes little sense when surrounded by the evidence. In addition, during earthquakes it has been found that (e) spatial arrangements within dwellings and birth order are directly related to mortality rates among children (Glass, Urritia, Sibony, Smith, Garcia, & Rizzo, 1977); (f) people are often injured by the furnishings and doorways under which they sought refuge (Arnold, Durkin, Eisner, & Whitaker, 1982) and (g) more effort is expended trying to protect property and possessions than protecting oneself or others (Ohashi & Ohta, 1984).

Although the public and the press often attribute patterns of behavior such as these to panic (see Abe, 1980), most researchers now conclude that panic is not an appropriate descriptor of such behavior, no matter how irrational or counterproductive it might appear to outside observers (Keating, 1982). By contrast, most current research in the area presumes that there is an underlying subjective rationale for the seemingly irrational actions that people take during earthquakes, fires, and similar incidents.

#### Urakawa Study

Research on human behavior during fires, and more recently earthquakes, has been the focus of scientific exchanges and collaboration between the United States and Japan for over 15 years. As we meet in Tucson, at least half a dozen

Japanese researchers are presenting papers on this topic at an International Symposium on Fire Science in Washington, D.C. It is in the tradition of these exchanges, that the following study of behavior during a recent Japanese earthquake was undertaken.

The major questions addressed in this study were (1) how much activity can people actually pursue during the period of strongest ground motion caused by an earthquake and (2) do they attempt to do any more than the minimal amount of activity required to protect themselves? In Japan, this minimal level of effort is expected to include turning off oil stoves, turning off gas valves, and getting under something that affords protection--in that order.

The March 21, 1982 earthquake near the town of Urakawa on the south coast of Hokkaido was selected as the site for this study because (a) it was the strongest earthquake to strike an inhabited area during 1982, (b) most structures remained sufficiently intact to permit on-site investigations after the incident, and (c) the residents of the town were minimally grief stricken because there were few serious casualties.

Urakawa is near the center of a very active seismic zone. In 1952 and 1968 earthquakes registering 8.1\* and 7.9 on the Richter Scale did serious damage to the town. In January, 1981 Urakawa experienced an earthquake with a magnitude of 6.7. In the 14 months between the January, 1981 and March, 1982 quakes, the residents of Urakawa experienced noticeable tremors nearly every day. Thus, it appears that the residents of this fishing and horse breeding community were as well prepared for this earthquake as any group has ever been.

The March 21 earthquake struck at 11:32:20 AM on a Sunday morning. The period of strongest ground motion lasted 30 seconds, with a magnitude of 7.1 on the Richter Scale and an intensity between 5.0 and 6.0 on the Japan Meteorological

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\* Equal to the main shock of the recent Mexico City earthquake.

Agency (JMA) Scale. There were 141 damaged dwellings in the town of Urakawa, most of which continued to be occupied after the quake. Only 9 of the 82 injuries reported in Urakawa were listed as serious. There were no fatalities.

A total of 41 persons who had been in their homes at the time of the earthquake were interviewed in August, 1982--five months after the incident. The subjects were selected on the basis of the calculated intensity of the tremor in the vicinity of their homes, which already had been determined by a research team from Hokkaido University (Ohashi, Fujibayashi, & Ohta, 1982).

### Procedure

We were especially interested in reconstructing the spatio-temporal sequences of the actions that had been taken during the earthquake as accurately as possible. A sequence of narrative and interrogatory interview formats that Keating & Loftus (1984) had found to be most effective in reconstructing complete and accurate accounts of behavior during fires was augmented by the use of specific spatial cues to localize and validate the temporal sequences reported by the subjects. On the assumption that people create accounts of their experiences in disasters to justify their own contributions to final outcomes, the subjects were initially encouraged to report what they had done or seen just as they remembered it. The remaining questions were ordered in such a way that successive responses would refine and correct the sequence in which each of the reported actions had actually occurred. All interviews were conducted in the spaces that the subjects had been occupying at the time of the March, 1982 earthquake.

After obtaining basic demographic and state-of-the-household data, three independent series of questions were asked pertaining to (a) the respondent's own actions during the period of strongest ground motion, (b) the respondent's observations of any structural or non-structural displacement during this period, and (c) the respondent's observations of the actions taken by other people during this period. A key aspect of this interview sequence was to identify the



precise vantage points from which building damage and the actions of others had been observed, and to use these to fix the respondent's location in space, thereby refining the spatio-temporal sequence initially reported for his or her own actions.

Insofar as possible, each subject actually walked through the sequence of actions and observations reported during each phase of the interview. During these walk-throughs, the locations at which each action reportedly took place, the vantage points from which each of the events occurring around the respondent had reportedly been observed, and his or her path of travel were plotted on measured floor plans of the dwelling which were prepared by two research assistants while the interview was being conducted.

Four distinct strategies were used to assure the completeness and accuracy of the spatio-temporal sequences being reconstructed. First, an open-ended narrative account of recalled activities was used initially to assure that a fairly complete record was obtained at the outset (see Keating & Loftus, 1984). To make sure that this first approximation was as complete as possible, the subjects were prodded in areas where omissions were expected to occur (e.g.: actions that had been initiated, but not completed). Second, the precise location of each action within each space was established and used to check the plausibility of the order in which events were reported to have happened. Third, the precise vantage points from which surrounding events had been observed were established and used to correct and fine-tune the spatio-temporal sequence of the respondent's own actions (i.e.: things reported to have been seen had to have been visible from the reported path of travel). Finally, the respondents actually walked through the entire sequence of actions and vantage points identified through the successive phases of the interview, thereby gaining an opportunity to reconcile what they had remembered with first-hand experience.

### Findings

Since the earthquake occurred on a Sunday morning, most working husbands were at home. At the onset of the strong shaking, the husbands generally waited to see what would happen while their wives immediately began turning off oil stoves and gas valves.

A typical scenario occurred in the home shown in Figure 1. The teenaged daughter (D) was sitting on a sofa, watching television. When the earthquake started she stood up, went 20 feet to the back door, stood there a while, heard breaking sounds, went 9 feet beyond the door and held onto the side of the detached garage. The mother (M) was sitting on the floor in front of the television which she also was watching. When the shaking started she turned the

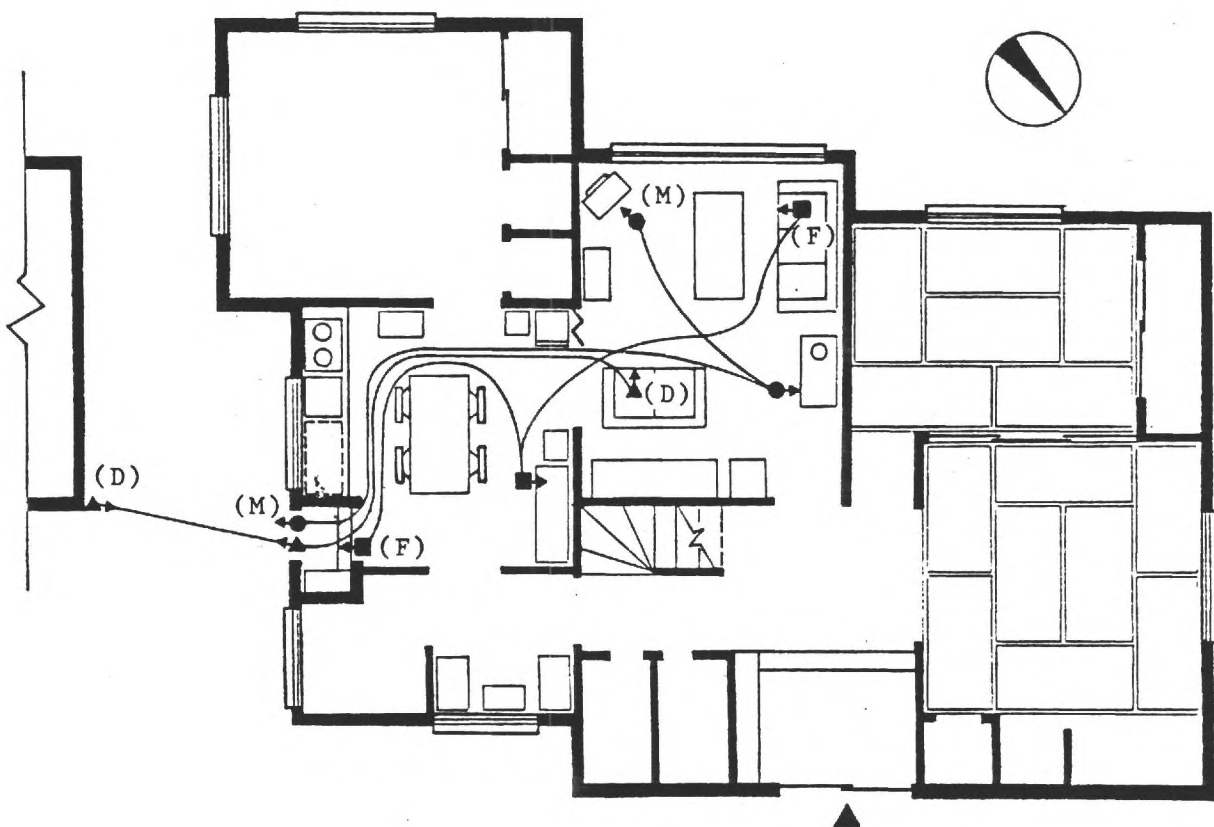


Figure 1. Movements of the daughter (D), mother (M), and father (F) in a typical Urakawa dwelling.

television off, went 9 feet to turn off the oil stove, went another 26 feet toward the back door, put on her sandals, and held the door open until the shaking stopped. The father (F) was sitting on another sofa, watching television. When the shaking began he remained seated to assess the situation, then he stood up and went 16 feet to hold onto a kitchen cabinet to keep it from falling. After he realized that this was futile, he went another 19 feet to the back door and stood behind his wife.

An analysis of the sample of 41 respondents revealed that they engaged in an average of five distinct actions during the 30 seconds of strong shaking. Thirteen of the 41 subjects (32%, including 75% of the men) reported that, when it first started, they remained in place until they assessed its severity. All but five of these ultimately went on to pursue other activities.

The subjects traveled an average of 27 feet from the time they first noticed the earthquake to the time that the strongest shaking stopped. Six subjects traveled over 50 feet during this period, with the greatest distance traveled being 174 feet. Specific findings related to reducing the risk of fire, protecting property, going outside, protecting others, and protecting oneself are as follows:

Reducing the risk of fire: Eighteen of the 41 subjects (44%) acted to reduce the risk of fire by traveling an average of 11'-7" to turn off their oil stoves. In a typical Japanese house, this is the equivalent of moving to another room. This action was most commonly taken by the women (especially the older women) and was most commonly the first action taken.

Seven subjects also traveled an average of 13'-3" to turn off the gas valves behind the kitchen range. In all, 20 respondents (49%) took one or both of these actions. The number of instances reported, the immediacy of the responses, and the distances traveled indicate that reducing the risk of fire was a

very high priority for the residents of Urakawa (even though most of the oil stoves were known to have been retrofitted with automatic suppression devices).

Protecting property: Fifteen of the 41 subjects (37%) traveled an average of 8'-6" to brace free-standing cabinets or shelves in order to keep these furnishings and their contents from falling to the floor. The fact that they traveled over 8 feet to do this, suggests that they were not just trying to prevent these things from falling on themselves, but were deliberately moving to the other side of a room to save their possessions. In several instances, the cabinets that were attended to were noted as having contained objects of special value to the respondent (e.g.: a bottle of Napoleon Brandy, a newly acquired television set). This action was most commonly taken by the younger men and older women--generally as the second or third action reported. On the average, the men traveled twice as far to protect property as did the women.

None of the subjects were successful in keeping their furnishings from falling, although many had been successful during the less intense earthquake 14 months earlier. Two of the respondents were struck by falling objects while they were holding onto their cabinets.

Going outside: Eleven of the 41 subjects (27%) went all the way outside at some point during the earthquake. Six more went as far as the outside door and waited. There were also several instances in which subjects tried, but had been unable to go outside. Those who actually went out traveled an average of 14'-5" to the exit door and an additional 21'-0" beyond the door. This action was most commonly taken by the younger women and was most commonly reported to have been the second action taken.

Three of the 11 subjects who went outside changed from their house slippers to their street shoes as they passed through the entry hall. Two of the 11 fell as they stepped outside.



Protecting others: Nine of the 41 subjects (22%) held or assisted other persons (usually children) at some point during the 30 second period of strong shaking. This was commonly done by the younger women (though there were as many children present in the homes of the older women), and tended to occur later in the sequence of actions reported.

In many instances, the respondent held or embraced a child who was nearby and then took that child to another location (often outside). In other instances, the respondent traveled to a child at some distance and then stayed with him or her until the shaking stopped. Those who went to another person traveled an average of 9'-11" enroute, while those who led another person to safety traveled an average of 39'-8" with that person.

Protecting oneself: Three of the 41 subjects (7%) tried to protect themselves by getting under a piece of furniture or some other cushioning device. Only two were successful. One woman successfully got under a folding mattress that was normally used for sleeping. Another ducked into the bottom of her bedroom closet where she would be cushioned by the clothes hanging overhead. The woman who was unsuccessful reported that, as she tried to get under her kitchen table, her refrigerator began to fall onto the table and another cabinet began to topple onto the refrigerator.

These three women traveled an average of 15'-8" to seek refuge, which meant that they had to go to another room. A comparison of the 11 subjects who traveled an average of 14'-5" to get to an exit door with the the three who traveled an average of 15'-8" to take cover, suggests that the former course of action was perceived to be more advantageous than the latter. In fact, aside from the one woman who prayed to Buddha, seeking refuge for oneself was the least common action reported by the Urakawa residents.

In considering this further, it was found that there were very few pieces

of furniture that one could have gotten under in the 27 homes surveyed. At the onset of the shaking, only 8 of the subjects (20%) were in a room that contained a piece of furniture that could have afforded them protection. Eight more passed through a room that contained such furniture as the shaking continued (see Figure 1). However, of the 14 instances in which a respondent passed directly next to a piece of furniture that could have provided safe refuge, only one resulted in an attempt to get under it, and that was the woman who had been unsuccessful!

In sum, it was found that the older women who had experienced the devastating off-Tokachi earthquake of 1952 reacted immediately to reduce the risk of fire. They were also the most likely to try to protect themselves, although half of them either held onto cabinets or went outside. The younger subjects who had only experienced earthquakes that were weaker than the 1982 event, tended to pursue a number of high-risk actions that had been effective on previous occasions, such as bracing furniture or running outside.

Although the highly experienced and well prepared residents of Urakawa initially tended to respond appropriately by turning off stoves and gas valves that could have ignited fires, they ultimately began to pursue inappropriate actions as the shaking continued. Interestingly, 78% of the subjects in houses where the shaking had been the strongest (JMA=5.8) tried to brace their cabinets, compared with only 30% where the shaking had been the weakest (JMA=5.4). By contrast, only 11% of the respondents experiencing the strongest shaking tried to protect themselves or others, while 71% of those experiencing the weakest shaking did attend to others. This suggests that attention shifted away from people (behavior) and toward property (environment) as the ground movement intensified.

#### Behavior in Destabilizing Environments

Since the tendencies to brace furniture and to run outside, while not seeking refuge for oneself, run counter to what the highly experienced and well

prepared residents of Urakawa were expected to do, further consideration is given to explicating the underlying experiential rationale behind the pattern of responses found in this and other studies of behavior during earthquakes and fires.

Our interpretation begins with the notion that, under normal (stable) circumstances all attention is directed toward the changing opportunities and obligations associated with the people who are using or might use a setting. Thus, the activities and events overtly associated with people in the foreground are consciously and actively attended to, while the spatial organization and architectural qualities of the settings themselves remain inconspicuously out-of-awareness in the background. Normative expectations and spatial-behavioral repertoires are thus based upon and directed toward constantly changing activities and events occurring within stable settings that remain totally predictable and constant over time.

Fires and earthquakes are experienced as abrupt and dynamic changes in the spatial organization of physical settings and in all of their predictable architectural qualities. This constitutes a background-foreground reversal in which normally stable spatial arrangements and attributes become ambiguous and unpredictable, thereby commanding attention that is normally directed toward human activities and events. As the duration or intensity of the incident increases, people are compelled to attend to circumstances for which they have developed no effective behavioral repertoires or expectations. Their counterproductive attention to furniture and valued possessions is thus seen as a very rational response to a totally unexpected and ambiguous situation--not as panic.

The following conceptual framework (see Figure 2) for considering behavior during fires and earthquakes is based on studies of responses to the Urakawa (Archea & Kobayashi, 1984) and Sendai (Ohashi & Ohta, 1984) earthquakes and on the findings of numerous studies of human behavior during fires (see Canter, 1980).

Prior to the onset of the event (1), actions are governed by attention to constantly changing events and activities in the foreground. Expectations of specific people and stable circumstances or settings are latent--governing responses to ongoing activities only when triggered by specific incidents (e.g.: the arrival of a mother-in-law or the locking of a particular door). The highly predictable material content and appearance of the physical environment itself remains completely out-of-awareness in the background.

Following the onset of the event (2), increasing information from the background environment diminishes the possibility of attending to ongoing activities and events in the foreground, and actions begin to be governed by newly triggered aspirations of continued situational stability.

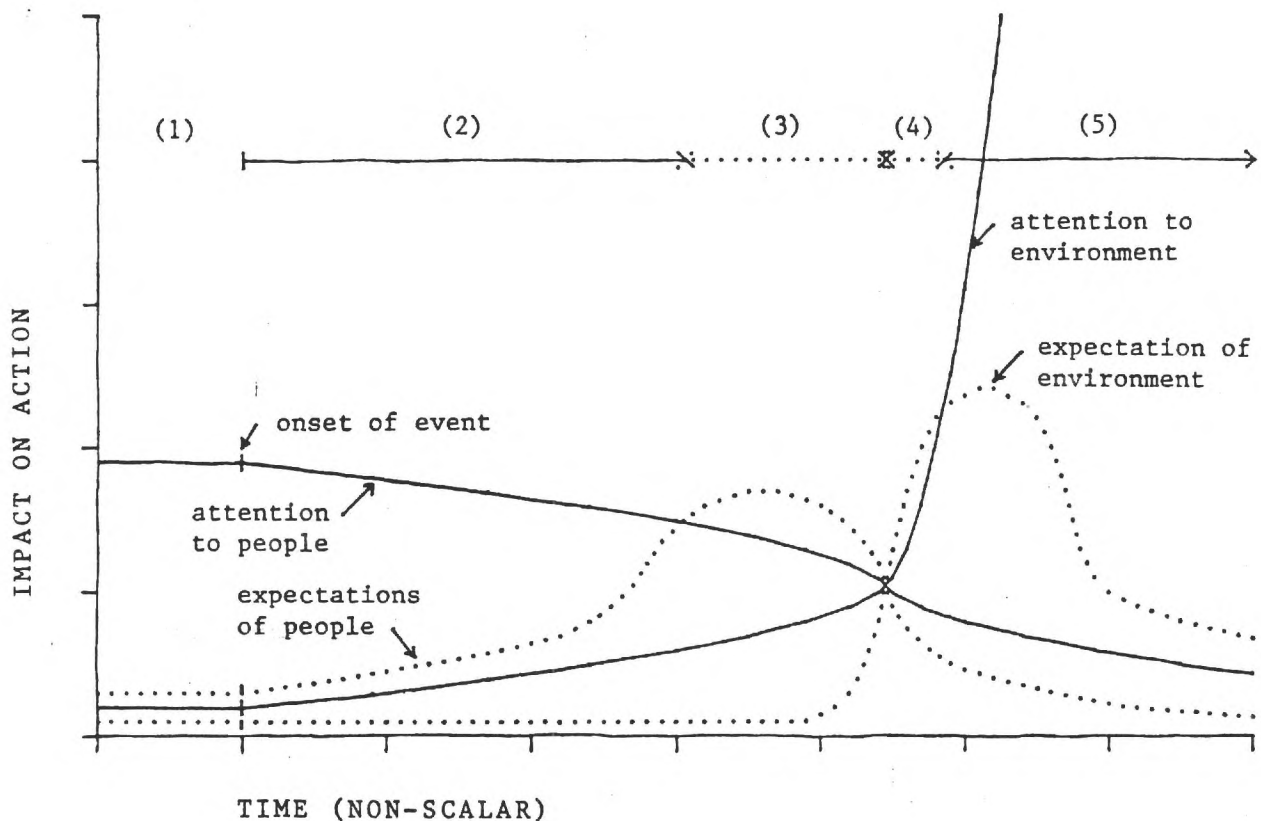


Figure 2. Aspects of attention and expectations governing action (1) prior to the onset, (2) following the onset, (3) just prior to acknowledging the reality, and (4) immediately following acknowledgement of fires or earthquakes and (5) as the threat intensifies.



Just prior to acknowledging the reality of the event (3), actions are governed by a brief expectation that the actions of others (if present) will provide the most appropriate guides to one's own actions. A rapid sequence of denial, wait-and-see, follow the lead of others, seek confirmation, and finally acknowledge the reality of what is actually happening will proceed as a function of each person's experience in the setting and in comparable events, as well as his or her roles in both.

Immediately following acknowledgement (4), information from the physical environment overwhelms information from activities and events, as well as any expectations of others or of situational stability. There is a reversal of background and foreground information to which people attend and actions suddenly begin to be governed by expectations of pre-incident spatial arrangements and attributes. Examples include retracing familiar routes (even when obstructed by smoke or debris), children getting into their beds during fires, and seeking stability outside during an earthquake (even pausing to change shoes enroute).

According to this framework, expectations developed in and for stable settings fail to anticipate abrupt changes in spatial arrangements and qualities, often leading to behavior that appears to be irrational to the uninvolved outside observer. Fires and earthquakes are counterintuitive, not only because they often involve uncommon physical conditions like flashover or liquefaction, but also because expectations and behavioral repertoires that are predicated on environmental stability place such conditions beyond the realm of imagination.

As the threat intensifies (5), all situational and environmental expectations become insignificant and action is governed by compulsive attention to the unexpected and ambiguous performance of building elements and contents which had no prior behavioral significance. Thus, people return from safety to recover photographs, jewelry, and furs--or try to brace their furniture and keep a new

television set from falling and breaking. In each case, attention is unavoidably directed toward these artifacts through a sudden recognition that they are actually in the process of being lost forever.

In primary settings like the home\*, the terminal and most destructive phases of fires and earthquakes focus attention on the impending loss of the very possessions and settings upon which one's expectations and behavioral repertoires are unquestioningly based--thereby focusing attention on the impending loss of an important aspect of oneself. Under such improbable circumstances, seemingly irrational acts like returning to retrieve objects from a fire or holding onto the cupboards during earthquakes can be interpreted as genuine, though futile, attempts to protect oneself. In effect, the very concept of self is expanded in destabilizing environments to encompass the stable environmental context upon which it is inevitably predicated.

This conceptual framework outlines a subjective and circumstantial rationality upon which behavior during fires, earthquakes, and other abrupt transformations of settings might be based. It presumes that the most predictable portions of a person's visual surroundings provide little overt information relevant to the conduct of interpersonal behavior and that events for which experience provides little or no precedent provide the dominant cues used to govern a person's response to changing opportunities and obligations (see Archea, 1984b). Such a framework subsumes virtually all of the actions that traditionally have been attributed to panic on the part of persons coping with rapidly destabilizing settings--thereby bringing the viability of that construct into question.

#### Implications for the Field as a Whole

People in general and environment-behavior researchers in particular have taken the physical environment for granted--especially its stability across time

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\* During fires in secondary settings like nightclubs, it has been found that people respond with a comparable form of subjective rationality (see Sime, 1985).

(and its uniformity across space). As researchers we have neglected the possibility that environmental stability is basic to the development of normative expectations, behavioral repertoires, and possibly the very concept of self. In doing so we may be missing an opportunity to fully explicate the relationships between these aspects of interpersonal behavior and the architectural qualities of the settings in which that behavior develops and becomes manifest.

In advancing the state-of-our-art we must not be misled by the fact that physical environments normally refrain from drawing attention to themselves. Once encountered and scrutinized, western-style buildings and rooms just sit there, heating and cooling themselves automatically, changing imperceptibly over time, commanding little attention, and requiring no direct response. Yet, it is precisely this stability that frees people to direct all of their attention and action toward the constantly changing array of opportunities and obligations associated with other people and their activities within settings.

According to this view, the degree of stability of the physical environment is a necessary precondition for the development of normative expectations and interpersonal skills. Environmental stability thus emerges as a legitimate aspect of environment-behavior research. The frequencies and rates at which settings can destabilize, together with the magnitude of these transformations, ought to be fundamental units of environment-behavior analysis. In addition to cataclysmic transformations like fires, earthquakes, and other natural disasters, research should also focus on less severe reconfigurations of physical arrangements and attributes which occur at perceptible rates (e.g.: storms, power outages, and mechanical breakdowns).

In addition to direct responses to such unpredictable events, research should also focus on the impact that their frequency and magnitude have on the half-lives of people's expectations and behavioral patterns. This concept of

the half-life of an expectation acquires meaning only when the environmental context of behavior is fully considered to be experientially variable.

Such issues suggest a particularly fruitful area for collaborative U.S./Japan research on environment and behavior. The hostile geophysical and climatic conditions prevailing throughout Japan appear to create very different expectations of environmental permanence than those prevailing throughout the United States. They also create more opportunities to study the inevitable instability of physical settings and its ultimate impact on human behavior. This, together with the Japanese tradition of actively manipulating the physical boundaries of settings (see Takahashi, 1980), presents an ideal opportunity to respond to Michelson's (1970) seldom acknowledged plea of fifteen years ago--that we must treat the physical environment as a genuine variable. It would appear that this is an area in which Japanese researchers have a singular opportunity to correct a conceptual deficiency that continues to impoverish environment-behavior research in the West.

In urging a renewed response to Michelson's plea, caution must be taken since, even in Japan, environmental variance is inherently less accessible to the researcher than behavioral variance. This is because the former shrouds itself in a veil of constancy while the latter incessantly reveals a full measure of conspicuous change. Nonetheless, if we are to fully comprehend the physical environment's salience to human behavior, we must be as eager and as skilled at exploiting the rare occasions on which well-formed expectations prove to be ill-suited to abrupt transformations of the environmental background as we have traditionally been to the far more prevalent occasions on which stable environments can be shown to be ill-suited the specific capabilities, expectations, or intentions which configure the behavioral foreground.

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